

REMARKS

In this Amendment and Response, claims 39, 46 and 59 have been canceled, and claims 1, 30, 38, 40, 47, 48 and 60 have been amended. Accordingly, claims 1, 30-35, 37, 38, 40-44, 47-56, 58, 60-62, 64 and 65 are currently pending. The Official Action of October 21, 2003 indicates that claims 30-65 are pending. That statement is incorrect as claims 36, 45, 57 and 63 were canceled previously, and claim 1, not indicated as pending in the Office Action, was in fact never canceled.

In the Office Action, the Examiner rejected claims 1, 30-35, 38-41, 43, 44, 47-56, 59-61 and 64 were rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 5,897,370 to Joshi et al. (“the Joshi reference”). Claims 37, 46, 58 and 64 were rejected under 35 U.S.C. § 103(a) based on the combination of Joshi and U.S. Patent No. 5,962,923 to Xu (“the Xu reference”). Claims 42, 47, 62 and 65 were objected to as depending from a rejected base claim. These rejections are addressed below.

Rejections Under 35 U.S.C. § 102

The Examiner rejected claims 1, 30-35, 38-41, 43, 44, 47-56, 59-61 and 64 under 35 U.S.C. § 102(e) as anticipated by the Joshi reference. Specifically, the Examiner stated:

Claims 1, 30-36, 38-41, 43-45, 47-57, 59-61, 63, and 64 are rejected under 35 U.S.C. 102(e) as being anticipated by Joshi, et al. (US 5,897,370).

Joshi discloses the steps of providing a substrate comprising a contact hole in a dielectric layer which exposes a portion of the substrate (col. 6, lines 46-55 and 65-67), depositing conductive material comprising

aluminum (col. 5, lines 35-48), depositing an impurity into the conductor which lowers the melting point of the conductor and reflowing (col. 7, lines 28-34). The impurity comprises Ge, the temperature of the reflow is within the range recited in the instant claims (col. 8, lines 1-8). With respect to the limitation that the impurities migrate out of the hole, the formation of a eutectic (col. 7, lines 57-59) is interpreted as satisfying this limitation. With respect to the limitation of the percentage of the lowering of the melting point of the material, the fact that the reflow temperature is within the range recited in the claims is interpreted as satisfying this limitation. With respect to the limitation of the impurity being deposited after 70% of the conductive material is deposited, this limitation is satisfied by the impurity being deposited after the hole is filled satisfies "after 70%" because after the hole is filled includes after 70%. With respect to the limitation of the steps being performed simultaneously, this limitation is satisfied (col. 8, lines 35-39), by the GeH₄ being simultaneously deposited. The reflowing is included (col. 1, lines 28-33), as the temperature taught for deposition is (col. 1, lines 28-33) is the same as the reflow temperature (col. 7, lines 28-33). Because the GeH₄ may be flowed over the conductor, and then form the eutectic (Fig. 2b and col. 8, lines 1-7), this is interpreted as satisfying the limitation of the impurity migrating as recited in claim 53. The impurity remaining in place is satisfied by the codeposition embodiment (col. 8, lines 35-39).

Office Action of October 21, 2003, pages 3-4.

The Examiner further responded to the Applicant's position, as follows:

Applicant has traversed the argument made in the Advisory Action that the W portion taught by Joshi can be interpreted as a portion of the conductive layer because the W forms a hard cap and is not a portion of the conductive layer. Although the applicant's argument is factual, this argument is not persuasive with respect to the allowability of the claims, because a portion is defined as "a part", and a part of a whole can include the whole. It is believed that the definition of a part includes the whole as being a part.

Therefore, it is believed that Joshi continues to read on the claims.

Office Action of October 21, 2003, page 2.

The Applicant respectfully traverses the rejection of the pending claims. Anticipation under section 102 can be found only if a single reference shows exactly what is claimed. *Titanium Metals Corp. v. Banner*, 778 F.2d 775, 227 U.S.P.Q. 773 (Fed. Cir. 1985). For a prior art reference to anticipate under section 102, every element of the claimed invention must be identically shown in a single reference. *In re Bond*, 910 F.2d 831, 15 U.S.P.Q.2d 1566 (Fed. Cir. 1990). To maintain a proper rejection under section 102, a single reference must teach each and every element or step of the rejected claim. *Atlas Powder v. E.I. du Pont*, 750 F.2d 1569 (Fed. Cir. 1984). Thus, if the claims recite even one element not found in the cited reference, the reference does not anticipate the claimed invention.

As amended, claim 1 recites “forming an impurity layer in said conductor layer *only during about the last 30% of the deposition of the conductor layer.*” (Emphasis added). Claim 48, as amended, recites “depositing an impurity onto the conductive material *only during about the last 30% of the deposition of the conductive material.*” (Emphasis added). Joshi teaches only the general concept of reflowing a conductor in the presence of an impurity such as GeH_4 (see Joshi, col. 7, lines 29-35), but Joshi contains no teaching, suggestion, or illustration that the formation of an impurity layer only during about the last 30% of conductor deposition is desirable. Accordingly, Joshi does not anticipate independent claims 1 and 48, or the claims dependent thereon.

Claim 30, as amended, recites that the steps of providing a semiconductor substrate, depositing conductive material, depositing an impurity, and reflowing the conductive material and the impurity are *performed in order*. In contrast to the subject matter of claim 30, Joshi discloses the deposition of a conductor followed by the *simultaneous* introduction of an impurity and reflow of the conductor:

Thereafter, a GeH₄ gas is flowed across the top surface of the Al--Cu or Cu layer 12, and the vias are filled. Preferably, the GeH₄ is flowed at a pressure of 1 mT to 760 Torr, and more preferably 1 Torr, and at a temperature of 300° C. to 450° C., and more preferably 380° C. to 400° C. Using GeH₄ in combination with Al--Cu lowers the eutectic point of Al--Cu and fills the vias.

Joshi, col. 7, lines 29-35.

As an alternative, Joshi discloses that the deposition of the conductor layer and the impurity may be performed *simultaneously* with the reflow operation:

Alternatively to the technique described above, the lines and vias can be formed *in one step* by depositing the material into vias in combination with GeH₄ reaction and then patterning and etching the lines to form the interconnect structure.

Joshi, col. 8, lines 35-39 (emphasis added).

Joshi, however, does not contain any teaching, suggestion, or illustration that the steps of depositing a conductor, then depositing an impurity, and then performing a reflow operation may be performed as separate operations *in that order*, as recited in amended claim 30. Accordingly, Joshi does not anticipate independent claim 30 and the claims dependent thereon.

Amended claim 40, which now incorporates the recitations set forth in canceled dependent claim 46, recites “depositing an impurity *intermittently* onto the conductive material, *while the conductive material is being deposited.*” (Emphasis added). The Examiner has acknowledged that Joshi is silent with respect to intermittent deposition. *See* Office Action, page 4. The Xu reference is relied on by the Examiner in the Section 103 rejection discussed below to provide the disclosure of intermittent deposition. However, Xu does not in fact teach *intermittent* deposition of an impurity *while the conductive material is being deposited.* In support of this position, the Examiner cites the following passage of the Xu reference:

In the specific embodiment of the contact 118 shown in FIG. 1, *aluminum is used as a conductive material 117 which is deposited over the carrier layer 100 using traditional sputtering techniques.* To form a contact 118 the aperture 113 extends to a region of the underlying substrate 110, and it includes an exposed portion 120 of the silicon substrate 110 at the base 111 thereof. To prevent interdiffusion between the silicon and the aluminum, the carrier layer 100 also functions as a barrier layer. In this embodiment of the contact 118, the barrier layer 100 is formed of three sub-layers, which may, if desired, be formed in a single chamber. The first sub-layer 112 is a sub-layer of titanium which was sputtered from a target and partially ionized (10 to <100% ionization) before being deposited upon the surface of both silicon dioxide layer 111 and silicon base 110; the second sub-layer 114 is a layer of sputtered titanium which is partially ionized and reacted with nitrogen to form titanium nitride before it is deposited over first sub-layer 112, and the third sub-layer 116 is a layer composed of both sputtered titanium and titanium nitride deposited in a partially ionized state (10 to <100% ionization). After depositing the titanium layer 112, a thin layer of titanium silicide 124 may be formed at the bottom of via (aperture) 113 by high temperature annealing to provide the barrier layer between the conductor and the underlying substrate. However, it has been found that the carrier layer of the present invention will function as a

barrier layer without the need to anneal the carrier layer to form the titanium silicide.

Xu, col. 7, lines 21-48 (emphasis added).

In addition, the Examiner cites the following passage of Xu to equate the carrier layer 100 shown in FIG. 1 of Xu with an impurity that allows a low reflow temperature:

The carrier layer 100, once deposited, provides a conformal layer having a thickness of approximately 800 Å, leaving an interior volume 119 within the aperture 113 to be filled with the conductive material. The remaining volume 119 of the contact 118 is then filled by traditional, i.e. non-ionized, sputtered aluminum (or aluminum alloy) deposition with a reflow step performed at a relatively low substrate temperature on the order of 390° C. for 2 minutes to 350° C. for 10 minutes.

Xu, col. 7, lines 8-56.

Accordingly, the Examiner has equated the carrier layer 100 of FIG. 1 of Xu to the impurity deposited in claim 40. However, as set forth above, Xu states directly that the conductive material 117 is deposited *over* the carrier layer 100. The carrier layer 100 is not formed *while the conductor is being formed*. Thus, Xu does not teach “depositing an impurity intermittently onto the conductive material, while the conductive material is being deposited,” as set forth in amended claim 40.

Claim 60, as amended, recites “depositing an impurity into the contact hole onto the conductive material at a temperature that causes the conductive material to reflow, wherein the impurity causes the surface tension of the conductive material to lower *and wherein the impurity*

does not form an alloy with the conductive material.” (Emphasis added). In contrast, as stated by the Examiner, the Joshi reference discloses that the introduction of an impurity is performed in such a manner that a chemical reaction forming an alloy takes place:

After filling the vias and lines, the exposed aluminum, aluminum-copper or copper alloys are reacted with a gas containing germanium *to form a germanium alloy over the upper surface of the substrate.*

Joshi, Abstract.

Accordingly, Joshi cannot anticipate amended independent claim 60 or the claims dependent thereon because claim 60 specifically recites that the impurity does *not* form an alloy with the conductive material.

For at least these reasons, Joshi does not anticipate the Applicant’s present claims. Accordingly, the Applicant respectfully requests withdrawal of the rejection under Section 102 based on Joshi.

Rejections Under 35 U.S.C. § 103

The Examiner rejected claims 37, 46, 58 and 64 under 35 U.S.C. § 103(a) as being obvious over Joshi in view of Xu. Specifically, the Examiner stated:

Joshi is silent with respect to intermittent deposition.

Xu teaches intermittent deposition of impurity as shown in Fig. 1 and described in col. 7, lines 20-45 as the carrier layer. The carrier layer allows a low reflow temperature for the filling of the opening (col. 7, lines 48-6).

One of ordinary skill in the art would have been motivated to have carried out the impurity deposition intermittently in the process taught by Joshi as taught by Xu in order to obtain the same lowering of the reflow temperature as is achieved by the process taught by Joshi.

Office Action dated October 21, 2003, page 5.

The Applicant respectfully traverses this rejection. The burden of establishing a *prima facie* case of obviousness falls on the Examiner. *Ex parte Wolters and Kuypers*, 214 U.S.P.Q. 735 (PTO Bd. App. 1979). Obviousness cannot be established by combining the teachings of the prior art to produce the claimed invention absent some teaching or suggestion supporting the combination. *ACS Hospital Systems, Inc. v. Montefiore Hospital*, 732 F.2d 1572, 1577, 221 U.S.P.Q. 929, 933 (Fed. Cir. 1984). Accordingly, to establish a *prima facie* case, the Examiner must not only show that the combination includes *all* of the claimed elements, but also a convincing line of reason as to why one of ordinary skill in the art would have found the claimed invention to have been obvious in light of the teachings of the references. *Ex parte Clapp*, 227 U.S.P.Q. 972 (B.P.A.I. 1985). When prior art references require a selected combination to render obvious a subsequent invention, there must be some reason for the combination other than the hindsight gained from the invention itself, i.e., something in the prior art as a whole must suggest the desirability, and thus the obviousness, of making the combination. *Uniroyal Inc. v. Rudkin-Wiley Corp.*, 837 F.2d 1044, 5 U.S.P.Q.2d 1434 (Fed. Cir. 1988).

In the present case, there can be no *prima facie* case of obviousness. This is true because the combination of Joshi and Xu does not contain every element set forth in the Applicant's claims. All of the rejections under Section 103 are based on the proposition that Xu teaches the intermittent deposition of an impurity during the formation of a conductor. As set forth above with respect to the rejection of independent claim 40 under Section 102, Xu does not in fact teach the intermittent deposition of an impurity during conductor formation. Accordingly, the combination of Joshi and Xu cannot render obvious claims 37, 58 and 64. For at least these reasons, the Applicant respectfully requests the withdrawal of the rejection of claims 37, 58 and 64 under Section 103 based on the combination of Joshi with Xu.

Conclusion

In view of the amendments and remarks set forth above, the Applicant respectfully requests withdrawal of all of the Examiner's rejections. Furthermore, the Applicant asserts that an indication of the allowability of claims 1, 30-35, 37, 38, 40-44, 47-56, 58, 60-62, 64 and 65 is appropriate. If the Examiner believes that a telephonic interview will help speed this application toward issuance, the Examiner is invited to contact the undersigned at the telephone number listed below.

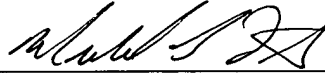
Authorization for One-Month Extension of Time

This Amendment and Response is filed in response to an Office Action mailed on October 21, 2003. Applicant hereby requests a one-month extension in the statutory period for response to the Office Action from January 21, 2004 to February 21, 2004 in accordance with 37 C.F.R. § 1.136. The Commissioner is hereby authorized to charge the Assignee's Deposit

Account No. 13-3092; Order No. MCRO:199--3/FLE (95-0057.03), for the fee associated with
this extension of time.

Respectfully submitted,

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